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REPORT ON

WRONG-WAY AUTOMATIC SIGN, LIGHT AND HORN DEVICE

June 28, 1965

65-48

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INTRODUCTION

As part of the recently completed Phase II of the Wrong-Way Driving Study* of the California Division of Highways, a special warning device to prevent wrong-way entry to the freeway was installed on an off-ramp near Sacramento. The objective of the installation was to determine whether such a device could effectively intercept vehicles proceeding the wrong-way on the off-ramp before they proceeded onto the freeway.

The warning device (Figure 1) consisted of a 5' x 3' white on red reflective background sign. The message was "GO BACK-YOU ARE GOING-WRONG WAY". Visual impact was increased by illuminating the sign only when actuated by a wrong-way vehicle. A standard 12" red signal head was placed below the sign 5' above ground level. The light was operated in the steady mode. Audio warning was accomplished by two electric horns, one continuous and the other pulsating.

All these components were actuated by a vehicle moving opposite to the normal off-ramp flow by using an inductive loop directional detector. A counter was installed

* T. N. Tamburri and D. J. Theobald, "Wrong-Way Driving Phase II, California Division of Highways, February, 1965". (U.S. Bureau of Public Roads cooperative project).

Figure 1

to record actuations and a timer was used to shut the components off after 20 seconds of operation.

This automatic device was installed on the northbound off-ramp into Stockton Boulevard from Highway 99 near the southern city limit of Sacramento (Figure 2). The Stockton Boulevard off-ramp had been determined to be the point of entry of a number of wrong-way drivers in a previous study. A ramp of this type is classified as "cul-de-sac or scissors type" in the "Wrong-Way Driving (Phase II)" report. The cul-de-sac and scissors are types often found, as in this case, where new freeway alignment through a town or city departs from the old highway alignment. This type of off-ramp then affords a direct movement to the former highway; and as in this case again, has a fairly heavy traffic movement. The annual average daily traffic on this section of the freeway is about 17,000, and during the peak month it is about 23,000. Off-ramp users number about 2,600 per day at this interchange while about 2,700 vehicles use the southbound direct connection on to the freeway. (The return movement.)

The automatic device became operative in July, 1964. It was modified several times until in about the middle of August, 1964 tests indicated that the system was completely reliable in detecting and counting all wrong-way vehicles and not giving false alarms with right-way vehicles. The modifications were necessitated because certain right-way truck and trailer combinations caused false calls.

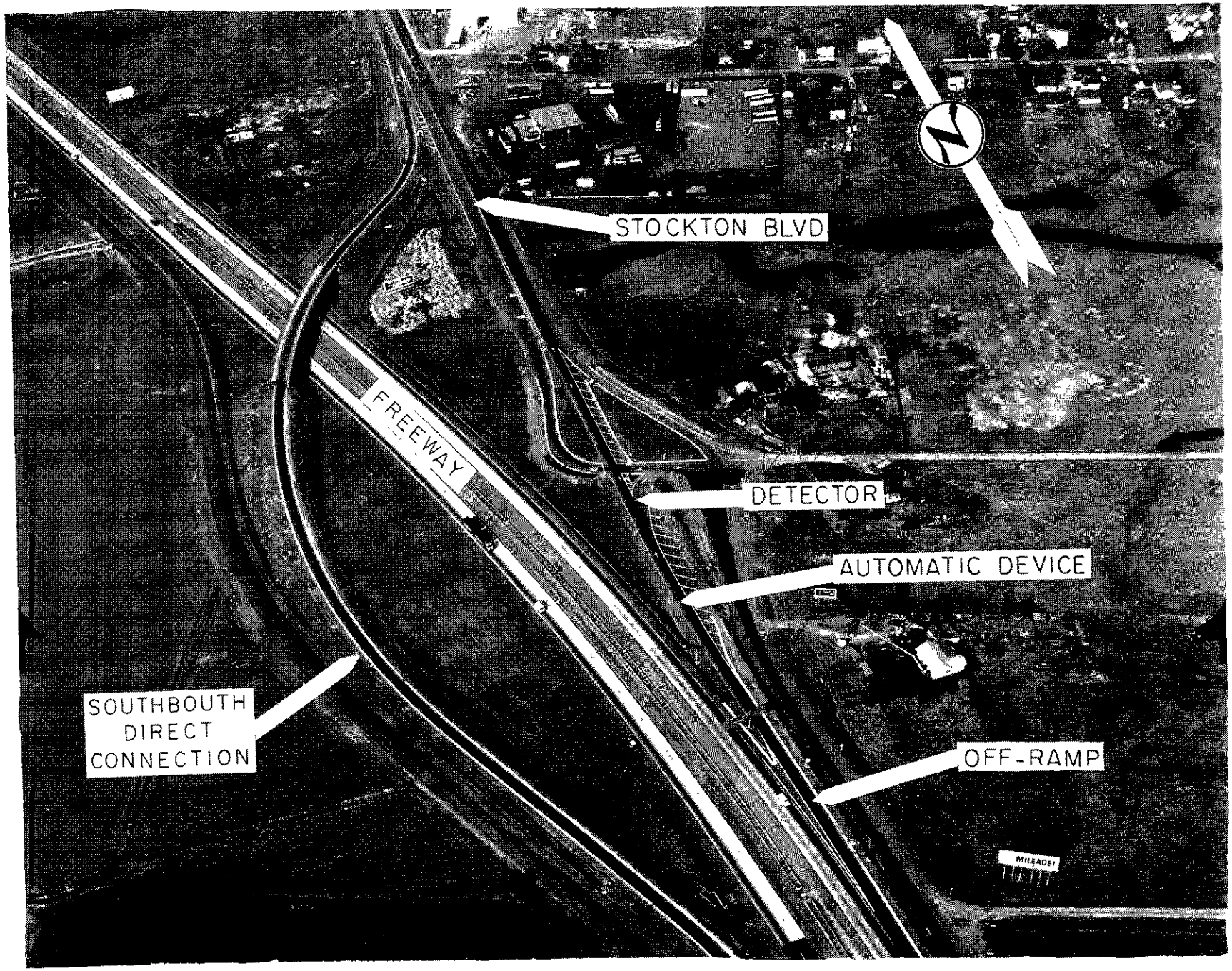


Figure 2

During July and August considerable newspaper, magazine and television coverage was devoted to the sign. Many national magazines and even a few foreign publications carried articles. Interest in these articles by the driving public was evidenced by the large number of letters received suggesting ways of preventing wrong-way driving.

Undoubtedly this publicity had an influence on the data gathered at this site. Interpretations of the data by the reader of this report should be made with the realization that there were intentional activations by curious volunteer wrong-way drivers as a result of the publicity.

The original plan for recording wrong-way moves was to install a counter to the output of the directional detector logic circuitry. Because of the previous difficulty with the directional circuitry and the relatively consistent high rate of actuations, it was decided that a movie camera should be added to verify the counter. Movies would also show driver reaction to the sign, thus supplying a measure of its effectiveness.

During the period of testing the effectiveness of the automatic device in stopping wrong-way drivers, it was decided to modify the directional and regulatory signing preceding and at the terminus of the off-ramp. The objective of these sign modifications was a reduction of the over-all occurrence of wrong-way entry at this ramp. This report then indicates the effectiveness of the sign changes in preventing wrong-way entry to the ramp, in the first place;

and the effectiveness of the automatic sign and horn device in intercepting the motorist who entered the ramp the wrong way anyway.

"BEFORE" SITE CONDITIONS

Figure 3 is a signing diagram of the "Before" condition. Proceeding south on Stockton Boulevard from Mack Road, these signs in order of appearance were:

	Sign Code	Sign Message	Location
1.	G78R	Freeway South	1000' North of Gore
2.	G78R	Los Angeles	500' North of Gore
3.	G42R	50 & 99	Gore of S.B. On-Ramp
4.	W17R	"STOP AHEAD"	250' North of Off-Ramp
5.	R7R	" KEEP RIGHT"	Nose of Island
6.	2-W5R (Lt.)	(Curve left arrows)	150' North of Off-Ramp
7.	W57R (Lt.)	(Left arrow)	35' from Off-Ramp
8.	R1R	"STOP"	At Off-Ramp
9.	R16R	"NO RIGHT TURN"	Beside "STOP" Sign
10.	R10R (Lt.)	ONE WAY	Channelization Island
11.	R11R	"DO NOT ENTER"	Wrong-Way Drivers' Left, 40' Up Off-Ramp

Pavement markings in existence on Stockton Boulevard (Figure 2 & 3) included a painted median area that widened approaching the direct connection to the freeway south. This median marking moved southbound vehicles to the right of the street directly in line with the southbound freeway connection. All drivers proceeding to the frontage

road beyond this point were forced to make a deliberate jog to their left by this pavement marking. To prevent southbound drivers from passing to the left of the bulb island, a double set of double yellow lines and then raised bars precede the island in excess of 600 feet.

Interviews by Highway Patrol officers and by Traffic Department personnel along with some speculation determined that wrong-way drivers at this location fell into four broad categories:

1. Intentional violators whose purpose was to actuate the sign, horns and signal.

2. Southbound frontage-road-bound drivers who absent-mindedly turned right too soon and drove into the off-ramp instead of the turning into the frontage road.

3. Drivers who for years had used southbound Stockton Boulevard (the old highway alignment) and were convinced they were going the right way. These drivers either ignored the signs or felt the signs were in error.

4. A group of drivers that strangely reasoned an opposite meaning to the existing directional signing. Their reasoning was that they did not want to go to "LOS ANGELES" (see sign list above) (389 miles south on Highway 99) but did want to go to Stockton (48 miles south on Highway 99). Instead of taking the direct connection, these drivers crossed the double yellow line, passed to the left of the island and proceeded directly up the off-ramp.

"AFTER" SITE CONDITIONS

Figure 4 is a diagram of the "After" condition of signing that pertains to potential wrong-way drivers at this location. Those marked with an asterisk on the figure are either changes or additions to the "Before" situation. The changes made were:

	Sign Code	Sign Message	Remarks
1.	G77R	South 99 North	300' North of Mack Road (New Sign) (Figure 5)
2.	G78R	Frontage Rd. 99 SOUTH	Replaced "LOS ANGELES" sign 500' North of Gore (Figure 6)
3.	R7R	KEEP RIGHT	Replaced smaller "KEEP RIGHT" without arrow
4.	W5R(Lt)	(Curve left arrow)	Removed median sign
5.	R11R	DO NOT ENTER	Replaced white on black with black on white (Added additional sign.) (Figures 7 & 8)
6.	R65R	WRONG WAY	New Signs added to R11R's (Figure 9)

CAMERA SURVEY

A 16mm movie camera was added to this wrong-way warning system for three reasons:

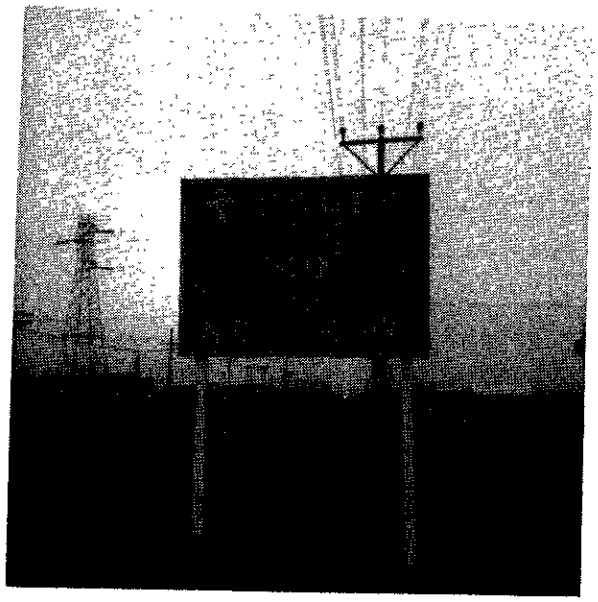


Figure 5

Figure 6

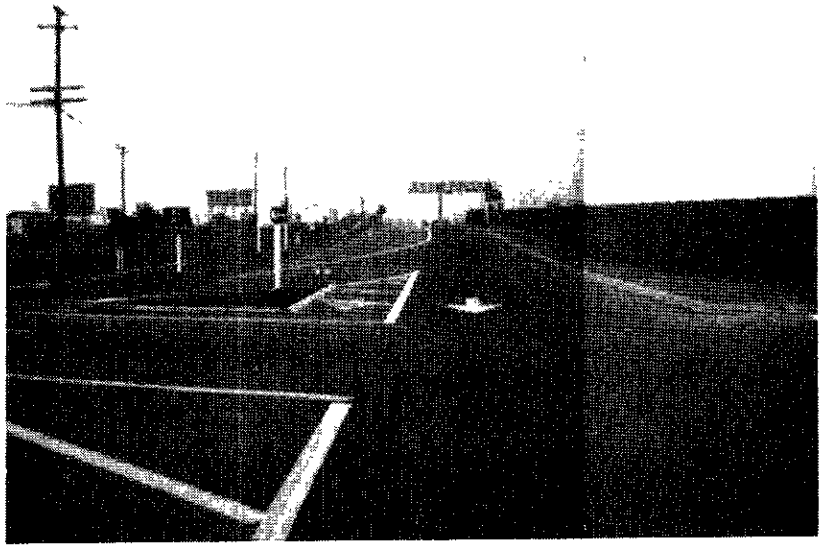


Figure 7
Off-ramp terminus before sign changes.

Figure 8
Off-ramp terminus after sign changes.

Figure 9

Close up of new R11R augmented with red background "WRONG WAY".

1. To determine the effectiveness of the warning system.

2. To verify the results of the counter.

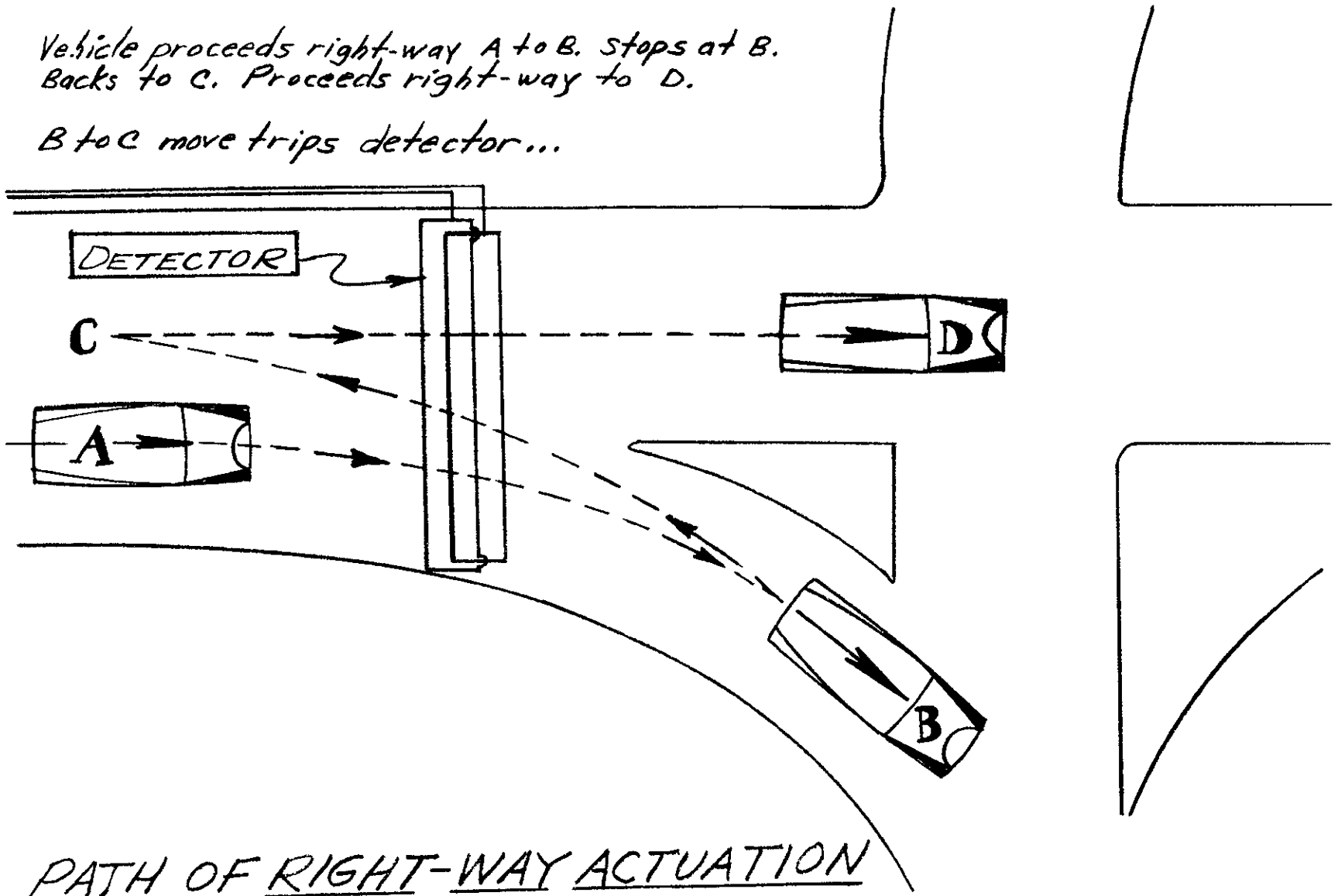
3. To see exactly what remedial action was taken by the wrong-way drivers after they had been warned of their illegal movement.

The camera was found to be an excellent source of information, but was also found to have some shortcomings. During the cold and damp winter months, mechanical malfunctions caused several incidents to go unrecorded. One entire film was lost due to improper operation of the "take up" reel.

Exposure of film occurred at a wide range of rates. Occasionally, when the rate was high, the entire footage of film was exposed and several incidents were unrecorded on film (but they were recorded on the counter).

Some right-way vehicles triggered the device by backing over the detector as shown in Figure 10. Occasionally a vehicle stopped just past the detector on the C to D leg of the diagram and backed over the detector, probably intentionally.

"Passed sign" in Table I and II are those drivers who drove the wrong way past the automatic sign-horn signal device. Disposition of these drivers is unknown, but it does not necessarily follow that all of the six vehicles in Table I that passed the sign continued out on the freeway the wrong way. Each sequence was timed for about a 20-second exposure. Several other vehicles passed the sign but backed



PATH OF RIGHT-WAY ACTUATION

FIGURE 10

TABLE I

STOCKTON BLVD. OFF-RAMP AUTOMATIC DEVICE-MOVIE RESULTS

Roll No.	Month	Elapsed Days (a)	Number of Wrong-Way Incidents								Right-Way Incidents*
			Daylight				Night				
			(b) Total	(c) Passed Sign	(d) Verified Voluntary Trips	(e) Actual Wrong-Way (b-d)	(f) Total	(g) Passed Sign	(h) Verified Voluntary Trips	(j) Actual Wrong-Way (f-h)	
Before Sign Changes											
1	September	7	4			4	2			2	1
2	October	7	3			3	5			5	0
3	October	11	7	(1)	1	6	5			5	1
4	November	5	1	(1)		1	2			2	5
SUBTOTAL BEFORE SIGN CHANGES		30	15	(2)	1	14	14	(0)	0	14	7
After Sign Changes											
5	December	10	1			1	2	(1)		2	3
6	December	15	-			-	4			4	4
7	January	8	1			1	-			-	3
8	January	7	1			1	3	(1)		3	3
9	January	5	1			1	1			1	7
10	February	8	-			-	1			1	5
11	February	13	-			-	1			1	5
12	March	13	-			-	2			2	3
13	March	7	2	(1)	1	1	2	(1)		2	2
14	March & April	13	2			-	2			2	2
SUBTOTAL AFTER SIGN CHANGES		99	8	(1)	1	7	18	(3)	0	18	37

* Includes Both Day & Night

into sight again before the movie terminated. Some of the six may also have backed up after the camera had stopped, or made U-turns at the freeway ramp gore to proceed in the correct direction down the freeway.

Five wrong-way drivers were identified by license numbers and interviewed. Three were grateful to have had the warning device prevent them from entering the freeway the wrong way. The other two fell into catagory 1, page 8 (intentional violators). Only five of the wrong-way drivers were interviewed because the license plates were not legible in the movies unless the vehicle stopped directly in front of the camera. Late in the testing period, a second camera with a telescopic lens was installed tnat took a single exposure of each incident. This second camera accounted for the last two owner identifications. A still camera could be used to record daytime incidents in future studies.

Testing actuations were, of course, deleted from the camera and counter incidents.

COUNTER SURVEY

A counter was installed in the warning device from the start of the study. Unreasonably high initial counts pointed out malfunctioning of the detector. Continued apparently high rates prompted installation of the movie camera. Manual checks confirmed that the counter was reliable under all weather conditions.

The counter gave the total number of actuations of the detector from all causes (right-way backups, wrong-way night, wrong-way day, tests, etc.). Because the camera data could be visually analyzed, the total observed incidents could be broken down into the percentage that any category of interest comprised of the total. Applying these category percentages to the total counter recorded incidents, the probable actual incidents that did occur in any category could be estimated. It had to be assumed, of course, that the previously mentioned camera malfunctions and the running out of film incidents occurred in a random manner in respect to the categories studied. This may not be the case since there was a tendency for the malfunctions to occur more frequently in damp (fog or rain) and cold weather during the after period and at night during both periods.

"Camera" and "Counter" periods were not the same duration. The camera was installed after the counter in the "Before" period. Known periods of camera malfunction were subtracted from the total days. This accounts for differences in the number of days shown for the camera counter in both the "Before" and "After" periods in Table II.

FINDINGS

1. Before any changes were made to the directional signing and before any new signing was added to the ramp, warning drivers not to enter, there was an average of one

TABLE II

ESTIMATE OF NUMBER AND RATE OF WRONG-WAY DRIVERS

CAMERA

BEFORE PERIOD (30 Days)

	Voluntary (a)	Right-Way (b)	Wrong-Way Day (c)	Wrong-Way Night (d)	Passed Automatic Sign (e)	Total (a+b+c+d)
Number	1	7	14	14	(2)	36
%	2.8	19.4	38.9	38.9	(5.6)	100
AFTER PERIOD (99 Days)						
Number	1	37	7	18	(4)	63
%	1.6	58.7	11.1	28.6	(6.3)	100

COUNTER*

BEFORE PERIOD (68 Days)						
Number	2	17	33	33	(5)	85
Number/Day	0.03	0.25	0.49	0.49	(0.07)	1.25
AFTER PERIOD (108 Days)						
Number	2	72	14	35	(8)	123
Number/Day	0.02	0.67	0.13	0.32	(0.07)	1.14

(*) All amounts except totals are products of camera % X Counter Total rounded to nearest whole number

wrong-way entry per day divided evenly between daylight and nighttime periods.

2. After the directional signing changes and the additional regulatory sign installations, the incidence of wrong-way entry to the off-ramp was reduced 54% (from 0.98 incidents per day to 0.45 incidents per day).

3. The signing change was more effective during the day when the reduction was from 0.49 incidents per day to 0.13 incidents (73%) compared to a reduction from 0.49 incidents per day to 0.32 (35%) for nighttime wrong-way entry. Improvement was probably better in the daytime than shown by these figures. Camera malfunctions were probably greater in the winter months during the colder nights than the warmer days. Omitted incidents probably were more prevelant at night.

4. Of the estimated total of 115 involuntary wrong-way entries recorded during the study period, an estimated 102 (89%) of the drivers stopped, backed up or turned around when they saw and/or heard the automatic sign-horn device. It is not known whether all of the remaining 13 drivers continued the wrong way onto the freeway. It is quite possible that some or all of them immediately crossed the median or made a U-turn at the ramp nose and proceeded down the freeway in the proper direction.

5. "False call" actuations of the automatic device by right-way ramp drivers who backed over the detector when they changed their minds at the ramp terminal channelization

increased from 0.25 incidents per day in the before period to 0.67 incidents per day in the after period. There was considerably more fog, rain and dark hours (winter) of operation during the after period.

CONCLUSIONS

New directional signs preceding the ramp in question and new regulatory and warning signs at the ramp terminal were effective in reducing wrong-way entry. The greatest improvement occurred during daylight hours (0.49 entries per day in the "Before" period to 0.13 entries per day in the "After"). Nighttime improvement was from 0.49 entries per night in "Before" to 0.32 per night in the "After".

The Automatic Sign-Horn-Signal device was successful in causing almost 90% of the drivers who entered the ramp the wrong way to take corrective action. However, some of these drivers undoubtedly reacted tardily to the "DO NOT ENTER" signs or to the clues presented by opposing traffic. Of the 11% of the wrong-way drivers who passed the sign, it is probable that some took corrective action at the ramp nose. Another logical assumption might be that the majority of the accident bound wrong-way drivers would be found among the 11% who passed the sign. Interviews with a very small number of the photographed drivers indicated that at least a portion of the likely candidates for an accident were among the 89% who stopped.

Actuations of the warning device by right-way drivers who followed the shoulder stripe to the right, then stopped and backed over the detector (Figure 10) increased considerably during periods of reduced visibility (rain, fog). These false calls occurred mostly at night.